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Teaching evolution to creationist students: the ultimate challenge

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ABSTRACT

Despite overwhelming evidence for the common ancestry of life and evolution by natural selection, ideas invoking direct creation persist, disrupting teaching evolution as a central biological concept. While originating within fundamentalist Protestantism in the USA, creationist views are now prominent elsewhere and in other religions. Responses by educators include ignoring evolution; excluding evolutionary topics especially provocative to creationist students; advocating evolution while ignoring, disparaging or ridiculing creationism; distinguishing between scientific and religious approaches before considering only the scientific; and acknowledging evolution and creationist positions as different world views that one may understand, but not necessarily accept.

Here, we argue that any chance of success in teaching evolution to creationist students requires elements of the last two of these approaches. Applying them requires understanding students' worldviews and the methods and limitations of science, as well as employing learning activities that engage, not alienate. In this context, we describe the creationist positions that may be encountered when teaching evolution, the fundamentals appropriate to teaching scientific method, and the teaching strategies of affirmative neutrality and procedural neutrality that educators may use to counter creationist views when teaching evolution. We regard understanding of the common ancestry of life and natural selection and other evolutionary mechanisms as threshold concepts that, once grasped, can transform students' interpretations of biology and possibly their world views.

Mentioning creationism in the context of science education may be a dangerous idea, but what is worse - to establish some common ground with creationist students in the hope of leading them to an understanding of evolution, or to leave them ignorant of any evolutionary concepts at all?

Key words: Affirmative neutrality, procedural neutrality, creationism, evolution education, intelligent design, threshold concept

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Introduction

Dobzhansky's (1964, p.449) 'reckless generalization' that evolution unites and explains all biology through the idea of common descent by natural selection found a receptive scientific audience. However, an evolutionary world view (or, as Dennett 1995 put it, 'Darwin's dangerous idea') has not found universal acceptance outside science. There are strong, coordinated and widely-held objections to evolution, drawn predominantly from elements within Christianity (Numbers 1992) and, more recently, Islam (Hameed 2008). Jewish concerns with evolution are also long-standing (Cantor and Swetlitz 2006a). Objections appear in various forms of creationism, which '… rejects natural scientific explanations of the known universe in favor of special creation by a supernatural entity' (National Academy of Science and Institute of Medicine 2008). Miller *et al.* (2006) concluded that approximately 33% of American adults rejected evolution. Outside the United States (US), Cornish-Bowden and Cárdenas (2007) noted increasing creationist activity in Turkey, the United Kingdom (UK), Europe and Latin America, driven sometimes by Islamic as much as Christian fundamentalism. Most Australians (70%) believe that evolution is occurring, while 9% disbelieve evolution (Wyatt and Stolper 2013).

Creationist views intrude in education. Berkman *et al.* (2008) found that more US citizens (10%) favoured teaching only Biblical creation in public schools than favoured teaching only evolution (8%), with 76% supporting teaching a combination. Islamic creationism is attractive to Muslim students in Europe, with Hameed (2008) reporting anecdotal instances of Muslim students leaving lectures on evolution. In Australia, the survey data are dated: 12.6% of first year biology students (20% in Sydney) believed in a special creation of humans within the last 10 000 years (Price 1992). This century, Brendan Nelson (then Commonwealth education minister) proposed including the creationist concept of intelligent design in school curricula, a positive view of creationism was a mandatory assessment component at a Queensland public high school, and the number of Christian schools in Australia has expanded, with at least some teaching creationism as an alternative to evolution (Maddox 2014).

Therefore students with creationist beliefs do enrol in biology classes at Australian universities. In that context, it is valuable to consider teaching creationist students to understand evolutionary concepts, if not necessarily to accept them, as an educational challenge requiring educators to understand their audience, understand and teach using the scientific method, and to interact respectfully (irrespective of personal views) to avoid possible alienation of creationist students. Therefore we begin by reviewing the diversity of creationist positions that may arise when teaching evolution, outlining key principles about the nature and limitations of science, and proceed to considering strategies that educators may adopt to enhance understanding of evolution by students holding creationist positions. These strategies include acknowledging that there are creationist worldviews and distinguishing between science and religion as a justification for teaching only evolution in the science classroom. Many students professing acceptance of evolution have poor understanding of evolutionary concepts (Alters and Alters 2001; Ingram and Nelson 2006; Isaak 2007), so emphasising understanding is not choosing 'second best.'

In so doing, we imply no doubt regarding the age of the earth, the power of natural selection and other mechanisms to produce evolutionary change, or the common descent of all life, nor do we advocate teaching creationism or the 'creation - evolution controversy'. Our point is that educators should understand creationist positions and strive for the goal that those students come to understand, if not accept, evolution. This is no different to addressing other conceptual problems that students may encounter in studying other topics in science (e.g., Francek 2013; Dangur et al. 2014; Greca and Freire 2014). Further, acknowledging creationist viewpoints is not a new idea; many evolution text books do this for the purpose of articulating the argument for evolution and illustrating the enormity of evidence for the facts that species change over time and that they derive from a common ancestor (e.g. see Ridley 2004; Futuyma 2009; Freeman and Herron 2007). Specifically addressing creationist viewpoints also recognises that the common ancestry of life and evolution by natural selection are threshold concepts (Meyer and Land 2003) that, once grasped, can transform students' interpretations of biology and possibly their world views. Mentioning creationism in a science class may be 'dangerous', but the alternative is to risk leaving some students – both creationist and non-creationist – ignorant of key evolutionary concepts.

Diversity of beliefs about creation and evolution

The creationist view that biological diversity arose from special creation by a supernatural entity embraces a wide range of different beliefs, freely acknowledged by creationists themselves (Wood 2011), that shade at one end of the continuum into entirely secular positions. Several authors have attempted classifications of different

Table 1. The continuum of views regarding creationism and evolution as defined from a Judaeo-Christian perspective (after Scott 2009 and Senter 2010).

Viewpoint	Characteristics
Flat Earthism	The universe, including a flat Earth at the centre and all biodiversity, was created in six literal 24-hour days less than 10 000 years ago.
Geocentrism	Accepts all the points above except that the Earth is flat.
Young-Earth Creationism	Rejects a geocentric view of the solar system in favour of a heliocentric one, but believes in separate creation of 'kinds' of plants and animals as stated in Genesis (with some adherents allowing the possibility of limited microevolution within the boundaries of kinds). The earth is considered to be between 6000 and 10 000 years old.
Gap Creationism	Believes in a pre-Adamic creation destroyed before the modern world was created. Rejects macroevolution, but may accept limited microevolution.
Day-Age Creationism	Believes that the 24-hour days of Genesis refer to unspecified periods of time over which creation occurred. Rejects macroevolution, but may accept limited microevolution.
Progressive Creationism	Accepts a gradual unfolding of creation over long geological periods. Rejects macroevolution, but may accept limited microevolution.
Creation Science	Seeks extrabiblical evidence for the supernatural creation of biodiversity. Rejects macroevolution, but may accept limited microevolution. It straddles several of the above categories. For example, some proponents adopt a Young-Earth position while others do not.
Intelligent Design Creationism	Asserts that some features of living organisms are 'irreducibly complex' or too tightly integrated to arise by gradualism and hence reflect the influence of a supernatural designer. Proponents may range across several of the categories above. Most accept the possibility of natural selection and limited microevolution, but not the evolution of higher taxonomic levels, 'irreducibly complex' structures or new animal body plans because mutation and natural selection are inadequate mechanisms.
Evolutionary Creationism	Accepts that evolution as understood by science occurs, but that God intervenes in the process.
Theistic Evolutionism	Accepts that evolution as understood by science occurs as the unfolding of a divine plan.
Agnostic Evolutionism	Holds that one cannot know if God was involved in evolution.
Materialist Evolutionism	Rejects any need for, or involvement by, God in evolution.

schools of creationist thought and their relationship to mainstream scientific opinion (e.g., Alters 1999, 2005 (Chapter 3); Alters and Alters 2001 (Chapter 4); Kojonen 2013). Scott's (2009) classification based on Judaeo-Christian perspectives, which we modify to incorporate extensions by Senter (2010), is the most comprehensive (Table 1). The two key points are the broad range of beliefs and the existence of positions that reconcile evolution with religious world views.

Islamic engagement with creationism has a unique religious and cultural context because much of modern science is new to many Muslim societies and is associated with colonialism. Nevertheless, science, including evolution, is seen as important in social progress and part of the image of Islam as a rational religion (Hameed 2013). Even if descriptions of creation in the Koran are interpreted literally, they fit comfortably with acceptance of an old earth (if not biological evolution), so very few Islamic creationists regard the earth as young (Hameed 2008). There are also readings of the Koran that are held to infer evolutionary theory, such that Islam is compatible with acceptance of evolution, even of humans (Ghafouri-Fard and Akrami 2013). Thus to compare these views with Scott's (2009) classification of Judaeo-Christian positions on creationism and evolution, Islamic creationists would approximate Gap Creationism, Day-Age Creationism or Progressive Creationism. Accommodatory positions would approximate Evolutionary Creationism and Theistic Evolutionism.

Other religious traditions are more accommodating of evolution. A 2008 survey of acceptance of evolution amongst adherents of different religions in the US found that 81% of Buddhist respondents and 80% of Hindu respondents agreed that 'Evolution is the best explanation for the origin of human life on earth' (The Pew Forum on Religion & Public Life 2008).

Scientific method

Just as understanding creationists' beliefs, and that there are religious positions that accommodate evolution, is important for educators seeking ways to engage students, it is valuable for all parties to remind themselves of the nature and limitations of scientific method. Gauch's (2003) PEL (Presuppositions – Evidence – Logic) model of science is an effective framework for a quick introduction.

Evidence and logic are the most commonly understood components of the model (and for some, the only parts they know). The evidence comes from systematic observation and experimentation, such that ideas can be tested to see whether they match with real world experience. The process of testing ideas against reality distinguishes science as a mode of inquiry (National Academy of Sciences 2008). Inductive and deductive logic connect the findings from individual observations or experiments into chains of reasoning. It is not necessary to be present when a phenomenon occurs to study it – one can apply logic to *post hoc* observations, in exactly the same way as forensic scientists approach a crime scene. This can be important in answering the creationist challenge 'were you there?' (Isaak 2007; Futuyma 2009).

Evidence and logic rest on presuppositions, which are beliefs essential to reaching a conclusion, but cannot themselves be proved (Gauch 2003). For example, to be able to test ideas scientists must presuppose that the world is, has been, and will remain, ordered and comprehensible; our sense perceptions (and by extension our instruments) give reliable, complete information; and that a 'real' world exists against which ideas can be checked and discarded if they do not fit. None of these presuppositions can be proved, but without them one cannot do science. For Gauch, this introduces the F word - faith, because without having faith in unprovable presuppositions science is not possible.

> *Intellectuals accustomed to the pat formula that 'Science has facts but religion has faith' may be shocked to see that science also has faith. Nevertheless, science is built on faith. If scientists rarely grasp or even sometimes contradict this, all that proves is that many scientists have a superficial understanding of their discipline's foundations. For scientists, seeing a coin in a cup counts as definitive evidence for the conclusion 'That there is a coin in the cup' precisely, only and decidedly because of scientific faith (Gauch 2003, p. 151).*

Before retorting that doubting that we are embedded in reality is ridiculous, the possibility that the 'real world' is a simulation or hologram is discussed seriously in philosophy (Bostrom 2003) and is the subject of advanced research in the physical sciences (Bekenstein 2003; Biron 2014). As Davies (2008) noted, our notion of science would be upended if we discovered that our world is not 'real'.

Presuppositions also place clear boundaries on scientific enquiry. For example, supernatural influences cannot be considered because they cannot be measured, controlled or manipulated to test their fit against reality, while invoking them as an explanation stops further search for natural causes. As Futuyma (2009, p 613) notes: 'scientists can test and falsify some specific creationist claims… , but scientists cannot test the hypothesis that God exists, or that He created anything, because we do not know what consistent patterns these hypotheses might predict.' Whether observed patterns in biodiversity fit those as predicted by evolution, as opposed to separate creation, *can* be tested. However, science cannot answer questions of supernatural intervention and religion, just as religion is not a science and should not be taught in the science classroom.

Responses to creationism in the classroom

An understanding of the scope of creationists' beliefs and the methods and limitations of scientific inquiry give context to choosing approaches for teaching evolutionary biology where creationist students may be present. Hermann (2013) listed four: avoidance, advocacy, affirmative neutrality and procedural neutrality (Table 2).

Don't use avoidance or advocacy

Avoidance (not teaching evolution) denies the centrality of evolution in biology, so it is not an option. Advocacy presents the science alone, but may not connect with creationist students by creating a perception of scientific arrogance. For example, Randy Olson noted after the premiere of his evolution/intelligent design documentary *Flight of the Dodos* that '... the single biggest impression they [students in the audience] walked away with was not that the intelligent design advocates were dishonest, which they clearly were ..., but that the evolution professors were arrogant, condescending and irritating' (Olson 2009, p. 127). Such an impression is hard to shift and may intensify fundamentalist religious beliefs (Ruse 2007). Even worse, treating those holding alternative views with scorn may '... only reinforce their belief that evolutionists are evil scum' (Isaak 2007, p. xxix). Armstrong (2010) goes further, arguing that religious fundamentalism is essentially a response to a perceived attack and that using evolution as an argument for atheism encourages denial of evolution as part of rejecting atheism. In response, students may 'learn for the test', telling instructors what they want to hear while holding privately to other beliefs (Long 2012). Thus we share Alexakos and Pierwola's (2013, p. 43) aversion for the view that '… students are essentially told to shut up and go to class' rather than engaging with issues as a route to genuine understanding.

Use affirmative neutrality and procedural neutrality

Affirmative neutrality and procedural neutrality offer more effective options, considering a range of positions on the origin of biodiversity in class without making value judgments, with a view to highlighting the distinction between science and religion as a justification for teaching only evolution in the science classroom (e.g., Tobin 2008; Alexakos 2009; Reiss 2010). Appreciating this distinction may be a threshold concept for many students (creationist and non-creationist alike), irreversibly transforming their understanding of science or allowing them to accommodate scientific and religious views (see Meyer and Land 2003 for a review of threshold concepts in general, and Ross *et al*. 2010 and Cheek 2010 for applications within the life and geological sciences respectively). Importantly, this is not to say that non-scientific views lack value. As Baker (2000) points out, questions such as 'Why is there anything rather than nothing at all?' are not amenable to scientific answers, but are suited to other modes of inquiry. Several pedagogical strategies can be applied under affirmative neutrality and procedural neutrality, which we believe are preferable to avoidance or advocacy.

Establish trust

Affirmative neutrality and procedural neutrality require trust between instructor and students, preventing a barrier of arrogance (Isaak 2007; see also the role of 'radical listening' in Alexakos and Pierwola 2013) or a sense of threat (Meadows 2007) when discussing

Table 2. Four broad approaches to teaching evolutionary biology where creationist students may be present in the class (after Hermann 2013).

Viewpoint	Characteristics
Avoidance	The instructor includes no evolution at all in the curriculum or avoids topics especially provocative to creationist students (Jones 2007). Such approaches may lead students to question established scientific findings or even to accept creationist viewpoints on topics avoided in class (Berkman and Plutzer 2011). Students may seek avoidance themselves by invoking universities' conscientious objection policies, but Scott and Branch (2008) highlight the impracticality of exempting biology students from a theory that pervades the entire discipline and the absence of unobjectionable alternative exercises to cover the material.
Advocacy	Creationist views are ignored. While reasonable from the valid viewpoint that only science belongs in science classes, excluding any reference to creationism can lead to a perception of scientific arrogance, especially if combined with attacks on religion (Ruse 2007) and even enhance resistance from creationist students (Isaak 2007; Jones 2007).
Affirmative neutrality	Presents a range of positions on the origin of biodiversity in class without making value judgements, with a view to highlighting the distinction between science and religion as a justification for teaching only evolution in the science classroom (e.g., Tobin 2008; Alexakos 2009; Reiss 2010).
Procedural neutrality	Students express their views rather than considering a summary from the instructor. Those views are then discussed briefly as a primer to studying evolution as the sole scientific explanation of the origin of biodiversity. Neither affirmative neutrality nor procedural neutrality involves 'teaching the controversy': instead, the focus is on acknowledging a range of views and explaining why only evolution is scientific (Ingram and Nelson 2006).

sensitive issues. Jones (2007) recommends against starting a general biology unit with evolution, and suggests establishing rapport first by considering other contentious topics such as research ethics or animal welfare. Terry (2009) proposes vegetarianism as an example. Buddhists accept the science indicating the nutritional value of meat, while choosing vegetarianism on ethical grounds. Jones (2007) and Jackson (2007) suggest animal welfare as another suitable topic. Such background is valuable later in explaining why evolution is science and creationism is not, while still valuing reasoning outside science.

Acknowledge theological positions that accept evolution

Jackson (2007) found that many of his creationist students were unaware of the diversity of religious opinion accepting evolution. By acknowledging theological positions that accept evolution, students can understand that there is not necessarily a controversy between religion and evolution (see Table 3 for resources for students). Allmon (2009) recounts an anecdote concerning an academic whose students wanted creationism taught alongside evolution. He assigned students a religion at random, asking them to research that religion's position on evolution (it is unclear whether 'religion' included denominations within major faiths). This independent research and inquiry reversed students' views, with most who completed the assignment agreeing that creationism should not be taught in science classes.

Presumably, the students uncovered theological views such as: 'The first chapter of Genesis, therefore, was not intended to be a historical account of the beginning of life but a meditation upon the nature of being itself' (Armstrong 1996, p. 18). In this long-lived tradition '... far from regarding revelation as static, fixed and unchanging, Jews, Christians and Muslims all knew that revealed truth was symbolic, that scripture could not be interpreted literally, and that sacred texts had multiple

Table 3. Readings and resources for instructors and students.

Reading	Description
For instructors	
Alters and Alters (2001)	Offers a comprehensive review of religious and non-religious objections to evolution, plus a rationale for teaching evolution and comprehensive suggestions for classroom approaches.
Alters (2005)	An update on the above.
Scott (2009)	Provides a thorough review of creationist and evolutionary positions, plus numerous readings.
Isaak (2007)	A quick, one volume reference for rebutting creationist scientific claims. More obscure or recent claims, including some arising from Islamic creationists, are rebutted at http://www.talkorigins.org/indexcc/.
Gauch (2003)	A detailed discussion of scientific method.
For students	
Gould (1997)	Gould's essay arguing for accommodation between evolutionary and theological positions can be a useful counter to arguments that acceptance of evolution inevitably leads to atheism.
Dobzhansky (1973)	A defence of evolution and rejection of biblical literalism by an accomplished scientist who took the view 'that the Creation is realized in this world by means of evolution' (p.129).
Armstrong (1996)	This extended, non-literal interpretation of Genesis illustrates a long-standing theological tradition of interpreting Genesis metaphorically. At the very least, the depth of scholarship might give a biblical literalist pause.
Parker (2009)	As an evolutionary biologist and Christian, Parker's original interpretation of the Genesis creation story is to read Geneis 1:14 ('Let there be lights in the firmament of the heaven to divide the day from the night; and let them be for signs, and for seasons, and for days, and years') as indicating the evolution of sight. His literal Genesis reading (albeit accepting that 'day' refers to an unspecified period of time) may appeal to more conservative students.
National Academy of Science and Medicine (2008)	This is a succinct account of evidence for evolution and rejection of creationism within a general framework of accommodating science and religion.
http://www.oldearth.org	At the rough and tumble level of online prosletysing, this Christian web site is devoted to challenging the views of young earth creationists and asserting the compatibility of science and religion.
Miller (2003)	This edited volume addresses difficult theological issues such as evolution and original sin, evolution and the soul, and combining special providence with non-interventionism. Other chapters extend these views to give a Christian ethic for environmental stewardship and biodiversity conservation that acknowledges evolution as the source of biodiversity.
Sager (2008)	Perhaps the most significant section of this detailed compendium of statements supporting teaching the theory of evolution is the significant number of positive statements from different religious groups. These statements are also available online at http://ncse.com/media/voices/religion.

meanings and could lead to entirely fresh insights' (Armstrong 2010, p. 310, see also Rabbinical Council of America 2005 for a Jewish perspective, Hameed 2008 for an Islamic one, or Auerbach 1953, p.15 for a secular exposition of '... the text of the Biblical narrative (being) so greatly in need of interpretation on the basis of its own content'). The conclusion is that religious students who know more theology are more likely to accommodate evolution (Jackson 2007; Jones 2007), or even to view creationist positions as 'bad science and bad theology' (Kojonen 2013, p.251) or 'bad science and inadequate religion' (Armstrong 2010, p.291).

Use historical examples

For those who agree with Gauch (2003, p. xv) that 'A humanities-rich version of science is more beneficial and engaging than a humanities-poor version', modern evolutionary theory can be introduced through a history of evolutionary ideas (see Miller and Totten 2009 for a description of an interdisciplinary undergraduate course along these lines and the text books Ridley 2004; Freeman and Herron 2007; and Futuyma 2009). Historical approaches reveal that evolutionary ideas antedated Darwin considerably (Bowler 1989; Ruse 2007; Freeman and Herron 2007), and that a generational shift in the scientific establishment akin to a Kuhnian paradigm change was necessary for widespread scientific acceptance of natural selection (Bowler 1989). It also emphasises how evolutionary world views raised challenging ideas about the age of the earth, environmental change, the role of natural selection rather than design in adaptation to changing surroundings, explaining natural phenomena without invoking miracles, and including humans within nature as subjects of evolution (Bowler 1989; Cantor and Swetlitz 2006b; Moore 2007). Arguments from design were dismissed decades ago, so the resurrection of intelligent design arguments in recent years is an unproductive atavism (Terry 2009).

Separate methodological naturalism from philosophical/ ontological naturalism

Excluding creationism from science classes because it is unscientific assumes that students understand the distinction between science and non-science. However, many introductory textbooks give only the briefest treatment of scientific method (Calver *et al.* 2009, Belk and Maier 2013 and Phelan 2015 are exceptions, devoting substantial chapters). A more detailed coverage prepares students to recognise that creationism is not science. In particular, it is valuable to distinguish between methodological naturalism – the exclusion of supernatural influences from science because their action cannot be controlled or manipulated to observe consequences in the natural world – and philosophical (or ontological) naturalism, which holds that the natural world is all there is and denies the possibility of the supernatural altogether (Poole 2007; Scott 2009; Freeman and Herron 2007).

The theistic evolutionist perspective accepts methodological naturalism, but not philosophical naturalism (Scott 2009). Numerous professional scientists, including some of exceptional attainment, accommodate evolution with their religion (e.g., Dobzhansky 1973; Collins 2006; Roughgarden 2006; Kelley 2009 and Miller 2009 within Christianity, Abouheif 2013 within Islam, and examples in Cantor and Swetlitz 2006a within Judaism), albeit sometimes in unconventional ways (Cherry 2006; Gwynne 2009). They are clear evidence of Dickerson's (1992, p. 27) declaration that 'Both the die-hard atheist and the theistic evolutionist can function as modern biologists with absolute integrity.'

Use inquiry learning

Inquiry learning, where questions are answered on evidence rather than values, accords with methodological naturalism and is well suited to teaching evolution (Alters and Alters 2001; Alters 2005; Meadows 2009, Bryant and Calver 2009). Undergraduate evolution texts routinely include a specific module on the evidence for evolution:

> *…we begin with straightforward observation, on the small scale. If someone doubts that species can change at all, this evidence will be useful. Other people allow that change happens on the small scale, and doubt that it can accumulate to produce large scale change, such as new species, or new major group like the mammals. We work from small-scale change to see how the case for larger scale evolutionary change can be made. (Ridley (2004, p45)*

Such evidence for evolutionary change on a range of scales draws on examples from across all disciplines in biology. For example, Senter (2010, 2011) examined the dinosaur taxon Coelosauria, which includes *Archaeopteryx* and other early birds. Creationists hypothesise that reptiles and birds are distinct taxa, while evolution implies transitional forms. Examination of morphological evidence from fossils using multivariate methods advocated by creationists shows that, contrary to creationist claims that *Archaeopteryx* was not transitional, it has strong linkages with early birds and dinosaur taxa. In our experience, inquiry learning and separately articulating the evidence for evolution in a structured argument is as important for students who come to our classes already accepting evolution, as it is for those who begin with creationist viewpoints.

Suggestions for curriculum planning and research

The issues above suggest a short list of dos and don'ts for teaching evolution:

- Do establish an atmosphere of tolerance and respect in classes early in semester.

- Do take time to teach scientific method, including its limitations, the distinction between methodological and philosophical naturalism, and that some important questions fall outside science.

- Do, when introducing evolution, make clear that the course will only cover science.

- Do explain to students that they are expected to understand evolution from a scientific perspective, but that does not mean that they must accept it. Isaak (2007) claims anecdotally that several educators report that this is a successful approach.

- Do mention briefly that authorities in many religious traditions, as well as many accomplished scientists, reconcile evolution with their religious beliefs. Give some sources for students to follow up if they wish. Alters (2005, pp. 9-10) notes: 'Two characteristics seem to be almost universally present among creationist students: (1) they are pleasantly surprised when they learn that their instructor has some knowledge about their most important beliefs, and (2) their admiration and respect for that instructor increases (sic) considerably because of that knowledge. These characteristics are usually helpful in a teaching milieu.'

- Do broaden your personal understanding of the issues by consulting some of the readings for educators in Table 3, and consider directing persistent creationist students to some of the references for students (also in Table 3).

- Don't teach religion. A brief mention of positions of accommodation is enough. Science, not religion, is the subject of the science curriculum. Students may consult some of the readings in Table 3, but they should not be coursework in a science class.

- Don't, even if you are an evangelical atheist, denigrate or ridicule religious belief. The result is usually hostility and disengagement.

With regard to research in the Australian context, Maddox (2014) points out the incongruity between an increasingly secular Australian society and the proliferation of religious private schools. Whether or not many of these schools are teaching creationism or contributing to significant numbers of creationist students entering Australian universities is unknown, because Price (1992) presented the results of the last major relevant survey of student beliefs. Updating these data, with special attention to students studying to be science teachers, will clarify the extent of creationism in the contemporary student population and its likely promulgation via the next generation of science teachers.

Discussion

Rejection of evolution is often held to be a serious issue of scientific illiteracy in the wider population (Alters and Nelson 2002; Mazur 2004; Miller *et al.* 2006), encouraged by promulgation of misconceptions of evolution in the popular media (Alters and Nelson 2002) and organised creationist lobby groups (Baker 2000). However, many sciences bewail misconceptions of concepts in their disciplines amongst the public or beginning students (e.g., Trevena and Reeder 2007; Sharma and Ahluwalia 2012). There are also many complaints of media coverage misrepresenting basic concepts or facts (Donnelly *et al.* 2009; Jaspal *et al.* 2013; Worsham and Diepenbrok 2013). Furthermore, climatologists (Helm 2011; Dunlap and Jacques 2013), medical scientists (Burnett *et al.* 2012) and conservation biologists (Ehrlich and Ehrlich 1996) all wrestle with lobbyists. What is unique in the case of evolution, though, is that biologists are supported by leading religious authorities who argue for the science – support that is rare or absent amongst the lobby groups in the other examples. It is that support that encourages us in our accommodation of creationist students through the pedagogical approaches of affirmative neutrality or procedural neutrality, rather than an advocacy approach that risks an intensification of rejection or resistance.

Some, such as Dennett (2011, p. 50) regard accommodating religion and science as misguided, because it will 'persuade few devout Christians and Muslims. ... Much better ... is to say yes, there is a conflict, and once again, science wins.' One extension of such philosophical naturalism is that atheism follows logically from acceptance of evolution (Dawkins 2006). We disagree with taking this view in a class setting (irrespective of personal beliefs), siding with Ruse (2007) who, as a self-described 'Darwinian and non-believer', argues that rejecting accommodatory positions harms the teaching of evolution by pushing people into conflict over deep, sincere beliefs, implies scientific arrogance, and contradicts the evidence from distinguished scientists of faith that religion and science are compatible. Armstrong (2000, 2010) claimed that all the fundamentalist movements she studied in Judaism, Christianity and Islam were primarily defensive, born of a fear of an external threat. Taking a 'science wins' approach will therefore entrench the fundamentalist position and not advance the goal of providing some understanding of evolution.

Adopting an accommodatory position can be controversial, with the case of Professor Michael Reiss, an evolutionary biologist, animal behaviourist, science educator, first ever Director of Education at the Royal Society, and ordained Anglican priest being a clear example of strong negative reactions to mentioning creationism. In 2008 Reiss argued in a presentation to the British Association for the Advancement of Science that creationism should be confronted in the classroom. His argument that teachers encountering creationist students should explain the distinction between creationism and science was misrepresented as advocating teaching creationism. The Royal Society initially protested against the misrepresentation and offered Reiss an opportunity to reply, but pressure grew and he resigned as Director of Education (Clery 2008; Alexakos 2009). It therefore cannot be stressed enough that accommodatory approaches do not teach creationism or a non-existent science-creation controversy, but distinguish between scientific and non-scientific modes of inquiry to allow those with strong religious beliefs to engage with evolution from the perspective of methodological naturalism.

Ultimately, educators choose teaching examples and methods based on personal experience and values, and on their students' backgrounds and needs. The way they present their material, allow for student differences and respond to challenges in class, can encourage students to be comfortable with dissent, even in deeply personal matters. These are fundamental aspects of good science communication and important teaching points for all students. Engaging with dissenting views may even correct some of the misconceptions about evolution held by non-creationist students. While strongly creationist students may not come to accept evolution, in an atmosphere that acknowledges their views while clarifying that they are not scientific (and acknowledges that science has its own limitations), it should be possible to increase their understanding of evolution and science in general. Such an educational goal is challenging, but the greater danger is to leave creationist students – and possibly non-creationist ones as well – ignorant of basic evolutionary concepts.

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